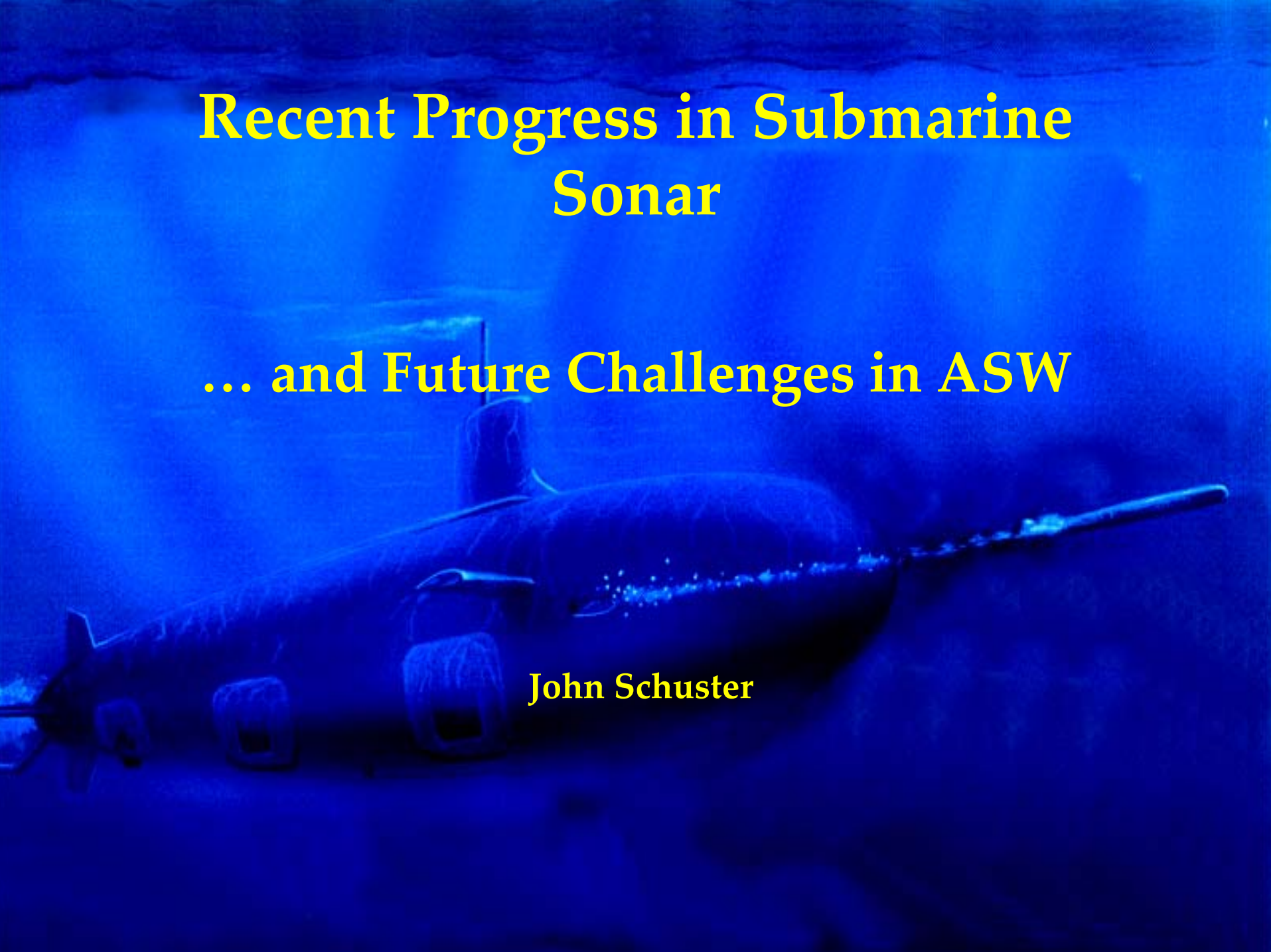


Recent Progress in Submarine Sonar

… and Future Challenges in ASW

John Schuster

Preface

- **In contrast to the technical papers of this conference I have chosen to present a survey of recent ASW progress and the urgent and formidable challenges to US ASW dominance**
  - ASW is arguably the major impetus behind research in underwater acoustics
  - The details of ASW technology are classified and mostly unavailable for open presentation
  - My government background is more attuned to technology management and to a focus on the larger picture
  - Our honoree has played a significant role in charting the course of ASW technology development

Outline

- The United States developed and maintained an unprecedented dominance over Soviet submarines during the cold war
- This ASW dominance suffered mightily when the Berlin wall fell
  - In lowered priority
  - In reduced funding
  - In blurring of focus

  and most of all
  - In loss of our ASW strategy
- Arguably since 1995 there has been revolutionary progress made in submarine sonars due to the Acoustic Rapid COTS Insertion (ARCI) and Advanced Processing Build (APB) programs
- Despite these impressive efforts, overall progress in ASW has been insufficient. Regaining ASW dominance is a critical national challenge

A (Very) Brief History of ASW

- **World War I**
  - Submarines demonstrate dramatic and lethal effects on surface shipping
  - Technology investments fail to an develop effective solution to the ASW problem
  - Convoy tactics “solve” the submarine problem

A (Very) Brief History of ASW (cont)

- **World War II**
  - Wolf pack tactics effectively target convoys
  - Significant but belated investment in understanding underwater acoustics
  - Active sonars deployed in numbers but are only effective at short ranges
  - Aircraft radar coupled with cueing (code breaking, radio intercept) provide large area ASW search and ultimately defeat the German U Boat force - the first example of ASW dominance
  - The development of the snorkel might have proven to be an effective countermeasure but came too late

A (Very) Brief History of ASW (cont)

- **Cold War**
  - World War II research in underwater acoustics coupled with the deployment of noisy nuclear submarines led to a new ASW paradigm
  - SOSUS large area passive detection provided robust effective cueing for tactical sonars on submarines, surface ships, and maritime patrol aircraft.
  - Passive detection allowed (mostly) covert interactions with Soviet submarines and resulted in an extended period of US ASW dominance
  - Spies within the US Navy gradually divulged the secrets of our ASW systems and fatally compromised our ASW strategy by 1990

A (Very) Brief History of ASW (cont)

- **Post Cold War**
  - Dramatic reduction of Russian submarine forces and curtailment of submarine patrols
  - Parallel reduction in US priority for ASW and reduction in ASW funding and system development
  - Led to loss of R&D funding, reduction in detection opportunities, reduced training and exercise budgets, and ultimately a loss of experience
  - At the same time the ASW threat began to change with emphasis on a broader array of threat countries deploying quiet diesel submarines in littoral waters
  - Most importantly a new ASW strategy was not developed

Submarine Superiority Study

- In 1995, the submarine force conducted a study to examine ASW performance in submarine operations
- This six month study examined all available sonar performance data and concluded that measured performance was not accurately predicted by the sonar equation, but could not pinpoint the exact reason for the discrepancy
- A major conclusion coming from the study identified the militarized computer driven sonar system as a severe impediment to introduction of new algorithms – and thus to progress in addressing evolving submarine threats

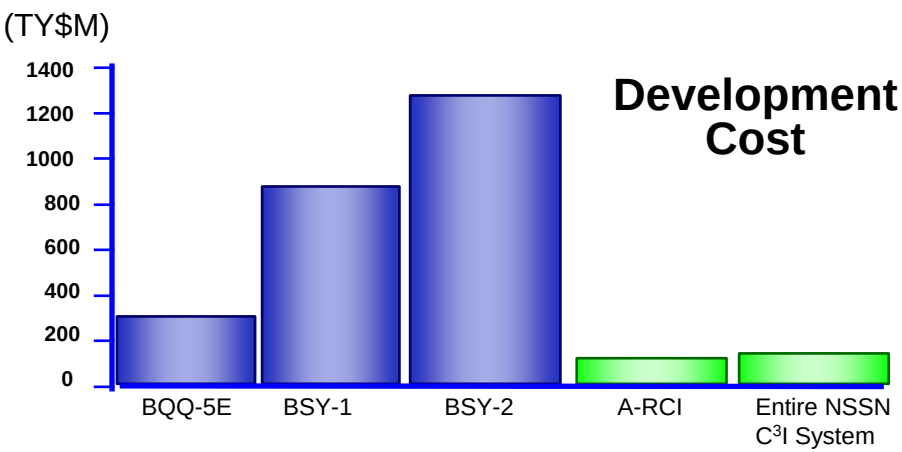
Evolutionary Sonar Improvement Program

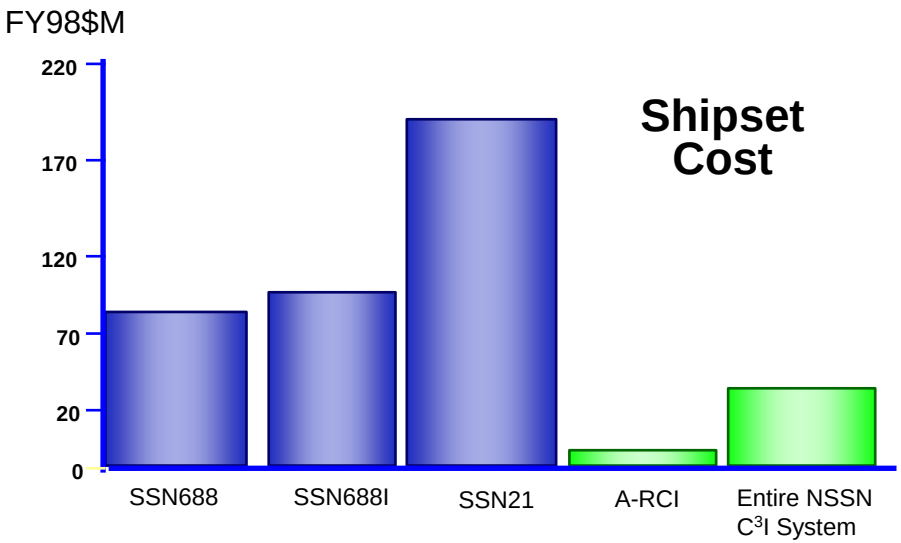
- **Establish and maintain a process to rapidly improve sonar system effectiveness with the following characteristics:**
  - Evolutionary improvements through iteratively exploiting the lessons learned in a "build-test-build" program
  - Focus on at-sea experimentation and data analysis
  - Utilization of encounter data recorded in existing systems
  - Signal Processing Innovations
    - *Implementation via COTS insertion in open architecture*
    - *Developing and testing prototype systems in parallel to BSY-1/2 systems*
  - Fleet involvement in testing and improvement of prototypes
    - *Fielding limited numbers of prototypes in forward deployed submarines*
- **Primary thrusts of this sonar improvement program are contained in the recommendations to follow**

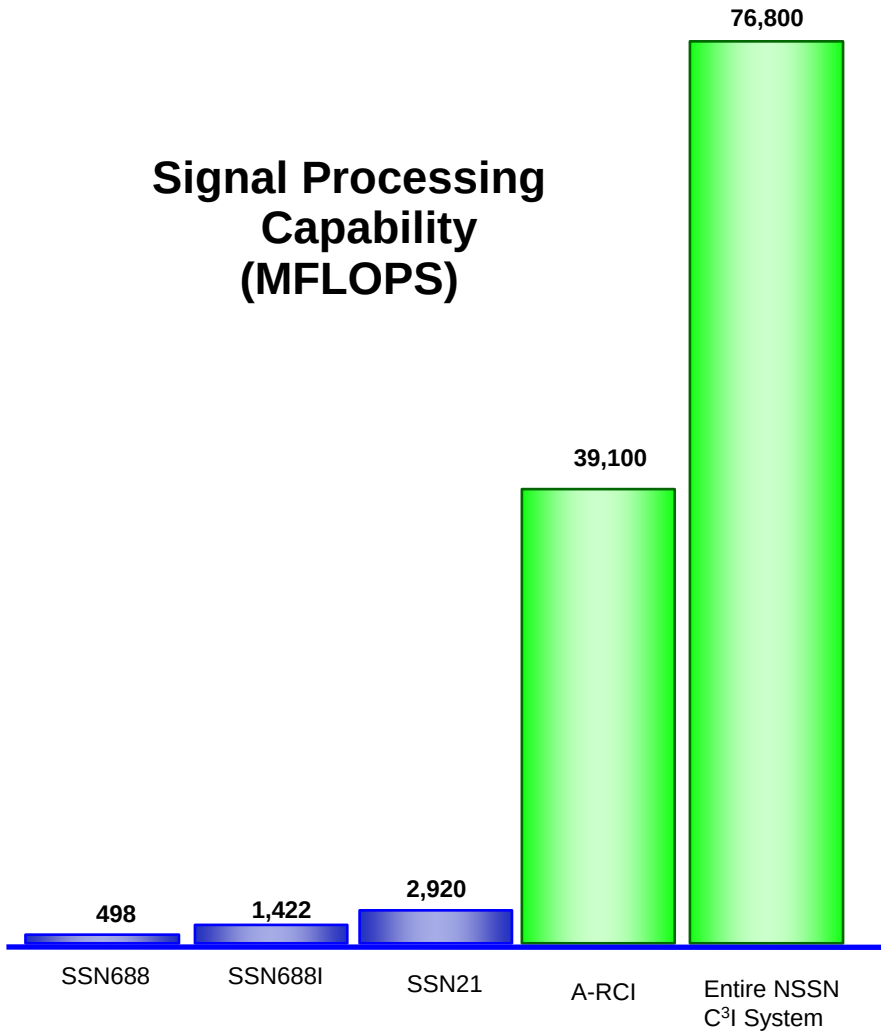
Response to the Superiority Study

- Submarine Leadership made a decision in the fall of 1995 to proceed with a program to rapidly replace existing submarine sonar systems with COTS hardware and to implement a process for hardware independent software development to allow more rapid and less costly development of new algorithms.
- The programs were called Acoustic Rapid COTS Insertion (ARCI) and Advanced Processing Builds (APB)
- In the interim before the new systems were available, a separate program was initiated to install temporary COTS processing systems on submarines to spur algorithm development and allow experimentation
- The programs were funded in large part within money already budget for maintaining the legacy sonar systems
- The result was a dramatic increase in submarine sonar processing capability

Submarine Combat System Cost - Reversing the Trend



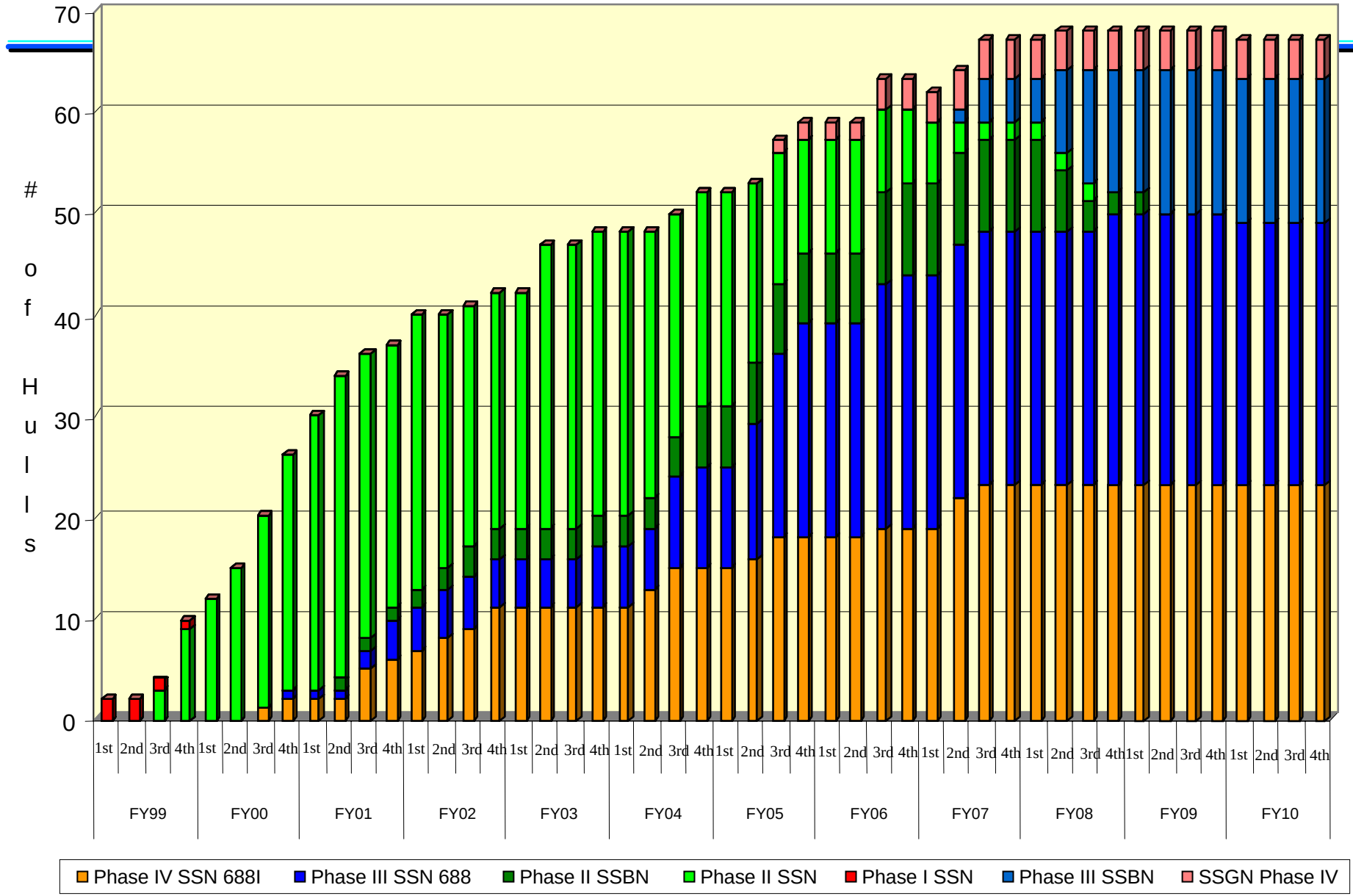




Militarized Legacy Systems

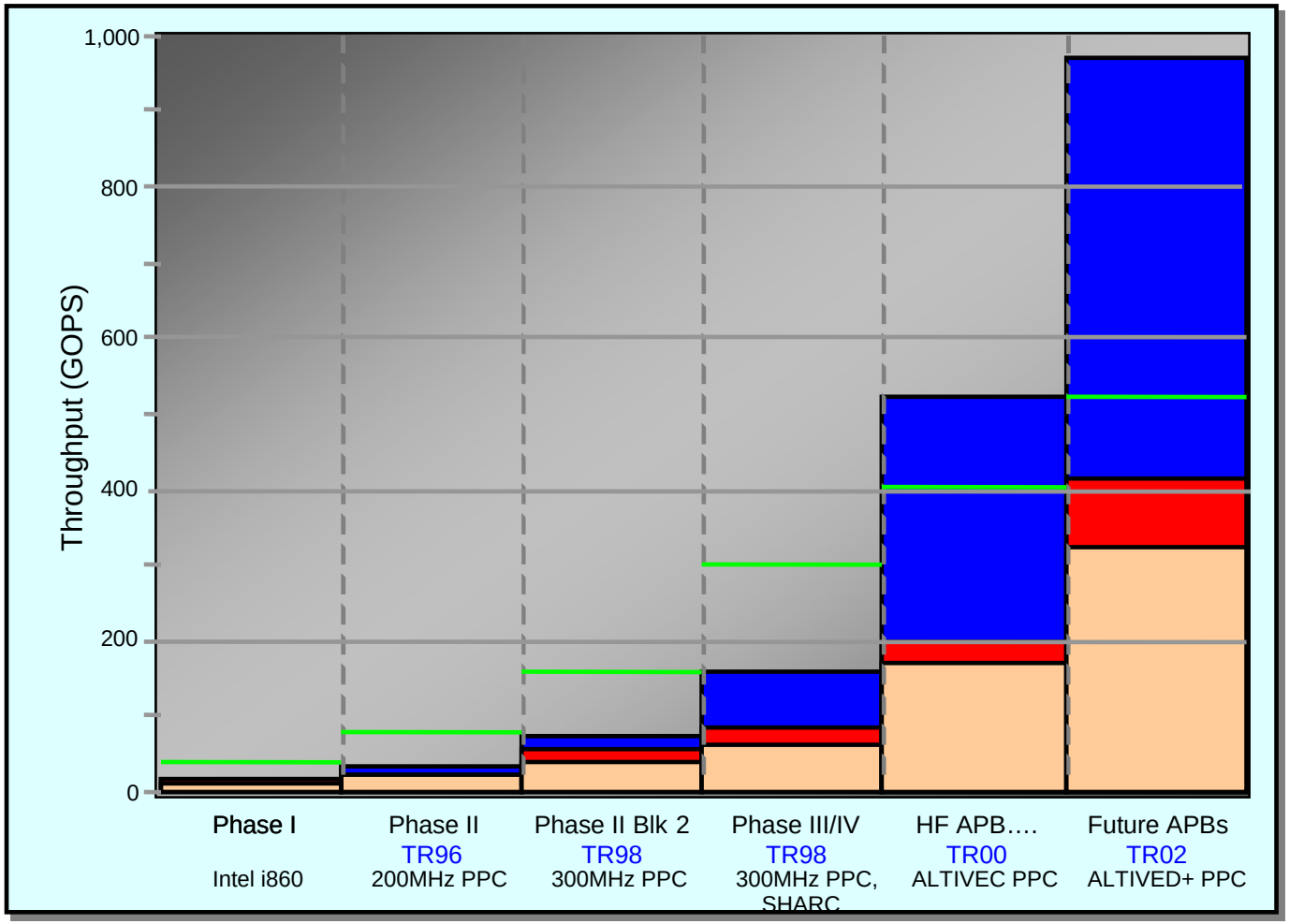
COTS Based Systems

A-RCI Installation Profile (PR03)



ARCI Processing Projection

With Technology Insertion



Utilized Processing Capacity
Installed Capacity
Fully Populated Capacity (Max drawers & cabinets)
Latent Demand Estimate
TRxx Technology Model Year

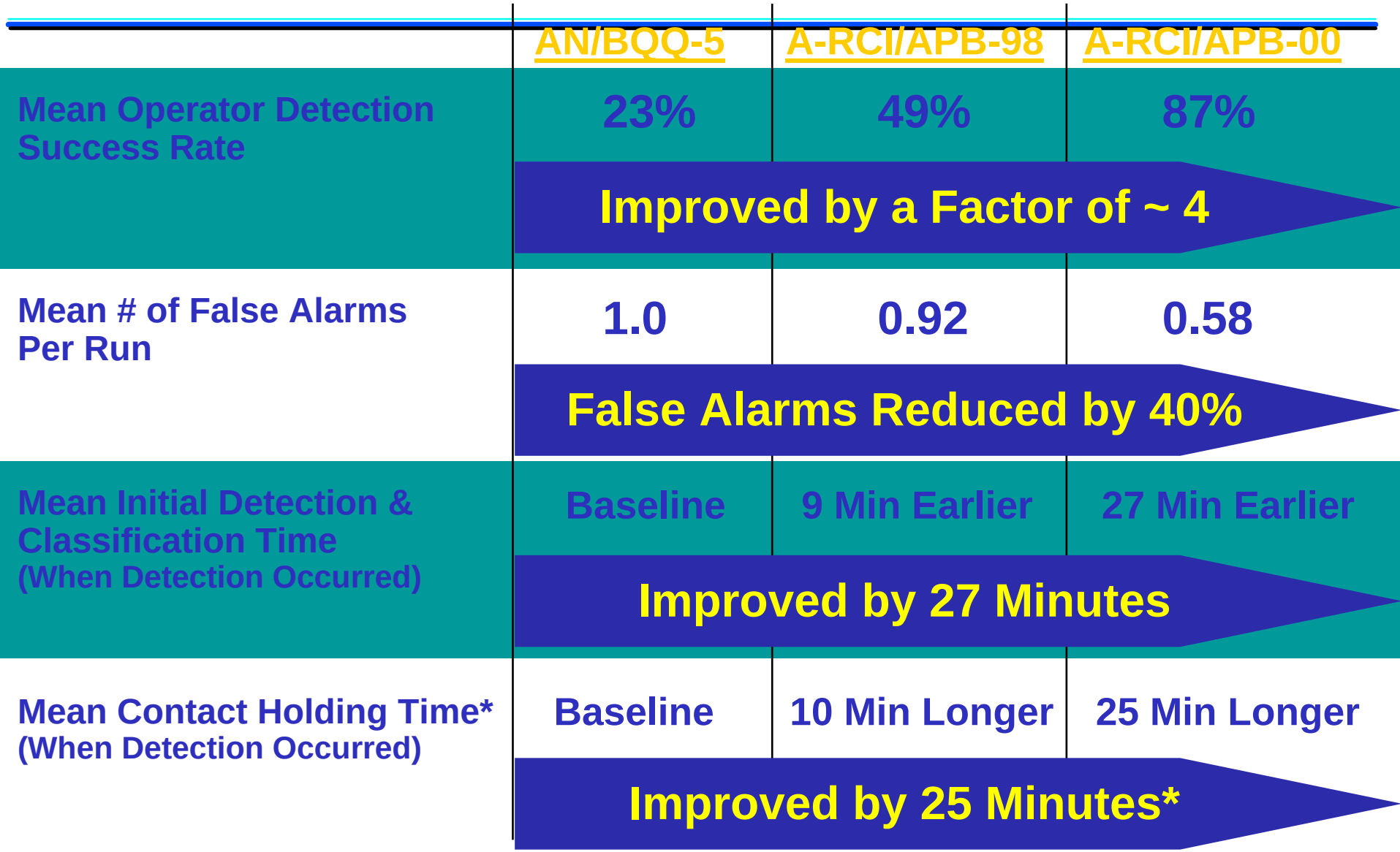
ARCI/APB Results

- Dramatically increased COTS throughput coupled with ease of algorithm development allows the implementation of almost any set of acoustic computations that can be imagined.
- Examples include:
  - Extensive operator decision aids
  - Alertment tools such as bell ringers
  - Adaptive beamforming
  - Beamforming of large sensor arrays
  - Complex environmental modeling
  - Near real-time everything

ARCI/APB Results (Cont.)

- Recommendations for disciplined testing using real world data were belated implemented with great effect in the ARCI Engineering Measurement Program
- Much more belatedly, the ARCI, AEMP philosophy has begun to be adopted across the ASW community

Towed Array Processing
Performance Improvement Trend



* Measured holding time limited by the length of recorded tape.

ARCI/APB Limitations

- Despite revolutionary technology advances, ASW gains have been modest
- Processing alone cannot solve the ASW problem
- Submarine improvements alone cannot solve the ASW problem

Discouraging News

- A Chinese submarine stalked a U.S. aircraft carrier battle group in the Pacific last month and surfaced within firing range of its torpedoes and missiles before being detected, The Washington Times has learned. THE WASHINGTON TIMES, November 13, 2006

- The skipper of the attack submarine Newport News was relieved of command Monday in Bahrain following a Jan. 8 collision with a Japanese oil tanker in the chokepoint of the Persian Gulf known as the Strait of Hormuz. THE NAVY TIMES, January 31, 2007

ASW Requirements

- There must be a straightforward ASW strategy that is well understood
- There must be a disciplined, physics based process to implement the strategy
- There must be routine and realistic exercising of the ASW strategy and the ASW systems to ensure dominance
- There must be sufficient intelligence collection to make our systems effective against our most advanced adversaries
- There must be sufficient security to protect our systems against compromise

Challenges for the ASW Community

- How can we work more effectively toward developing an ASW strategy rather than developing or improving specific systems?
- How can we convince the Navy to follow a disciplined, physics-based approach?
- How can we more effectively analyze proposed system concepts to identify critical strengths and weaknesses without full scale testing?
- How can we better integrate system design, signal processing, and environmental acoustics?

The ASW Reality

"No purpose, for example, is served by informing the scientific world that the Admiralty would very much like to be furnished with a sure and easy method of destroying submarines. This statement is perfectly true and perfectly futile."

British First Sea Lord (Balfour) circa 1915